SUSY Search Prospects at CMS

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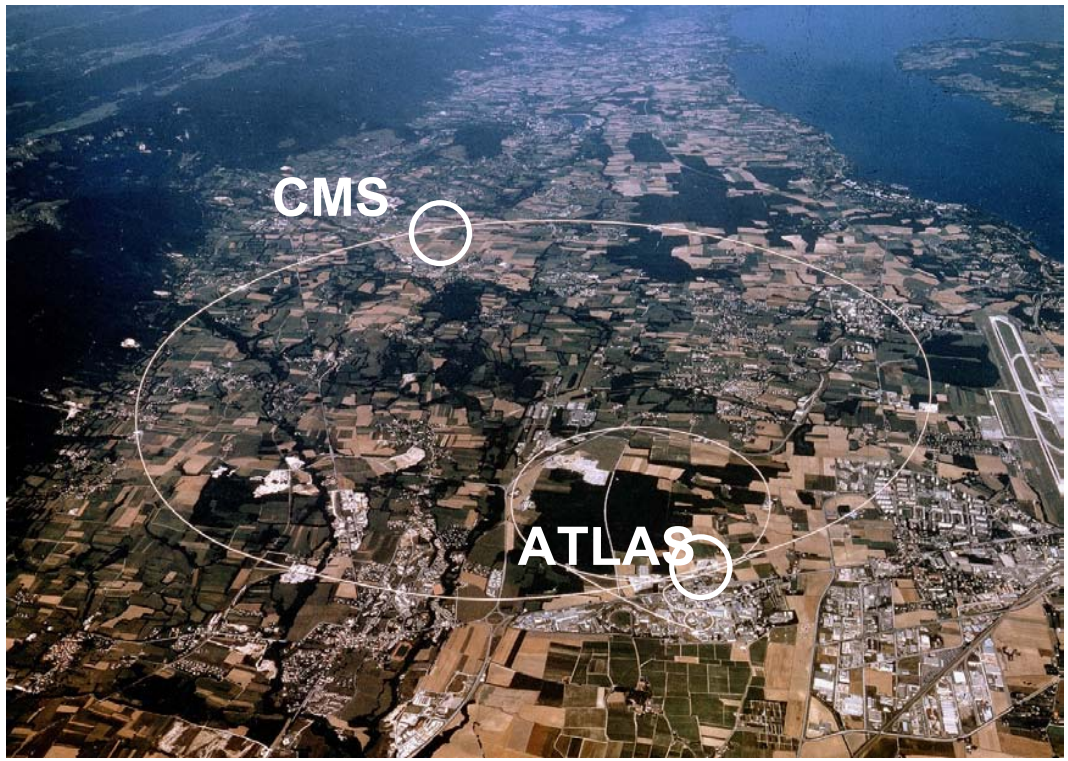
LHC and CMS
Physics Selection (Trigger)
MSSM Higgs
SUSY Spectroscopy
Conclusions

The LHC

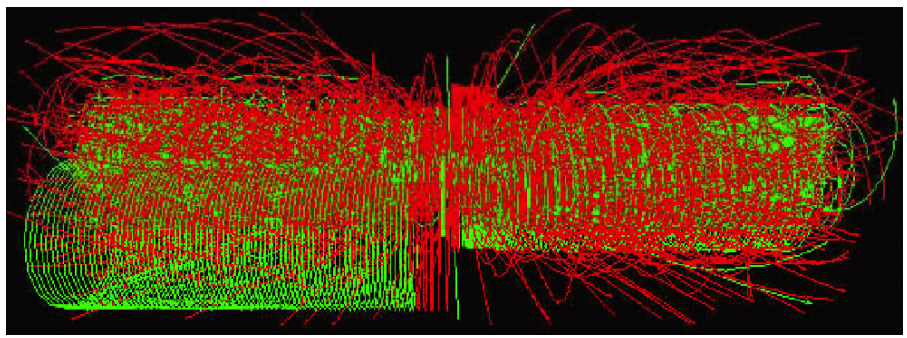


R = 4.5 Km
E = 7+7 TeV (pp)

crossing rate
=40MHz
(25nsec)

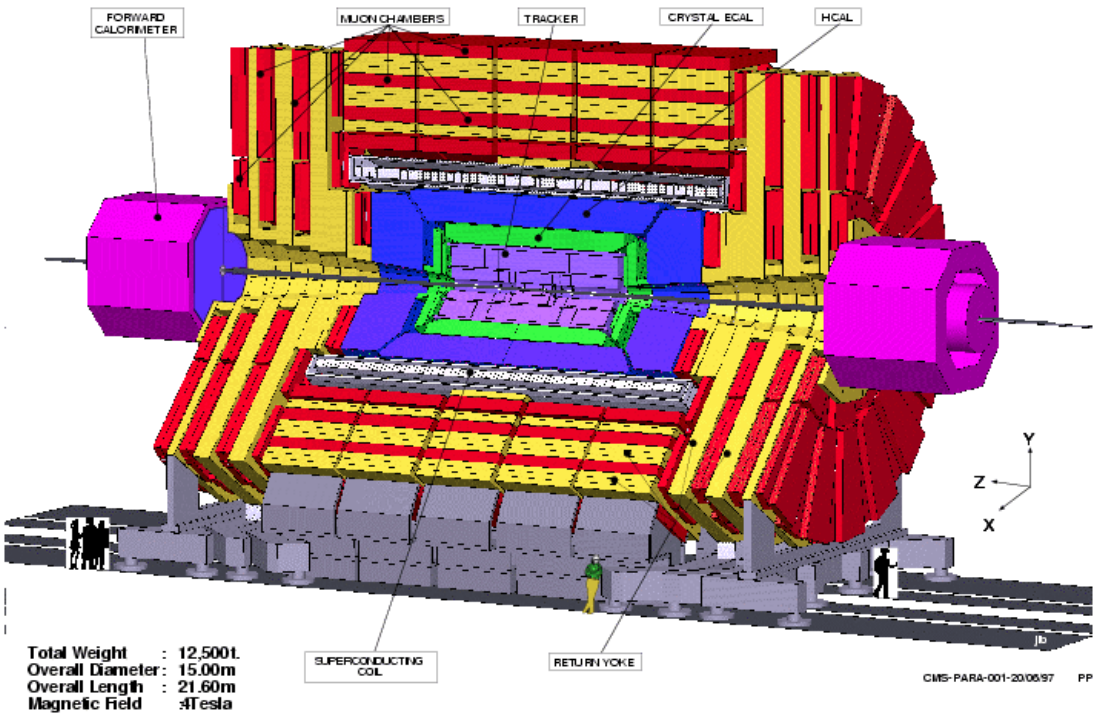
design luminosity
= $10^{34}cm^{-2}s^{-1}$

~20 pp interactions
per crossing
at design luminosity



h → 4 μ with 20 min. bias evt.

The CMS detector



Toal weight	12500 t
Overall diameter	15 m
Overall length	21.6 m

All silicon tracker
- micro strips (10M ch)
- pixel (40M ch)

(5.4m long, 2.4m Φ: $|\eta| < 2.4$)

Hermetic calorimeter
- ECAL: PbWO4 crystal
- HCAL: brass+scinti.

($|\eta| < 3.0$)

in 4 Tesla solenoid

(12.5m long, 6m Φ in)

Robust muon system
- DT+RPC (barrel)
- CSC+RPC (endcap)

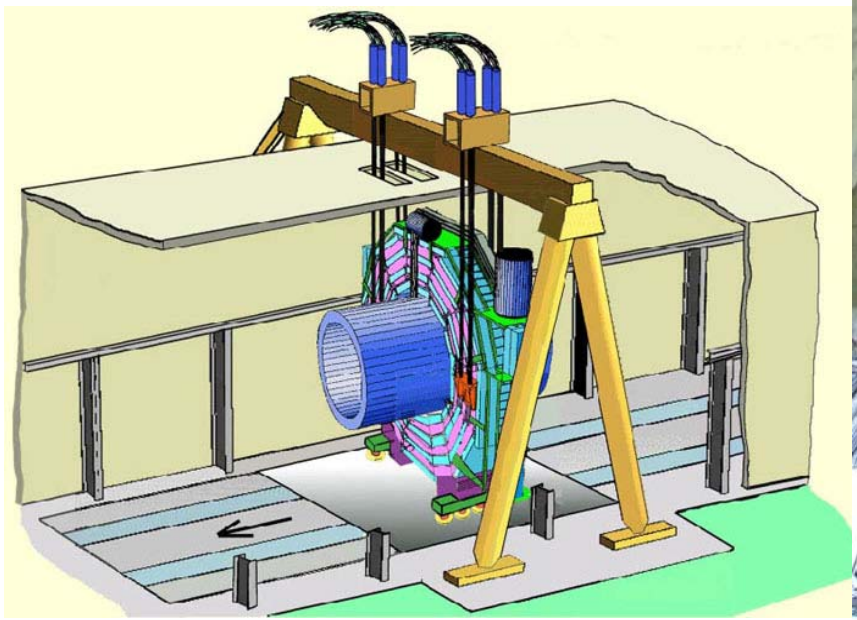
(in iron yoke: $|\eta| < 2.4$)

Fast cerenkov calor.
- quartz fibber

($3 < |\eta| < 5$)

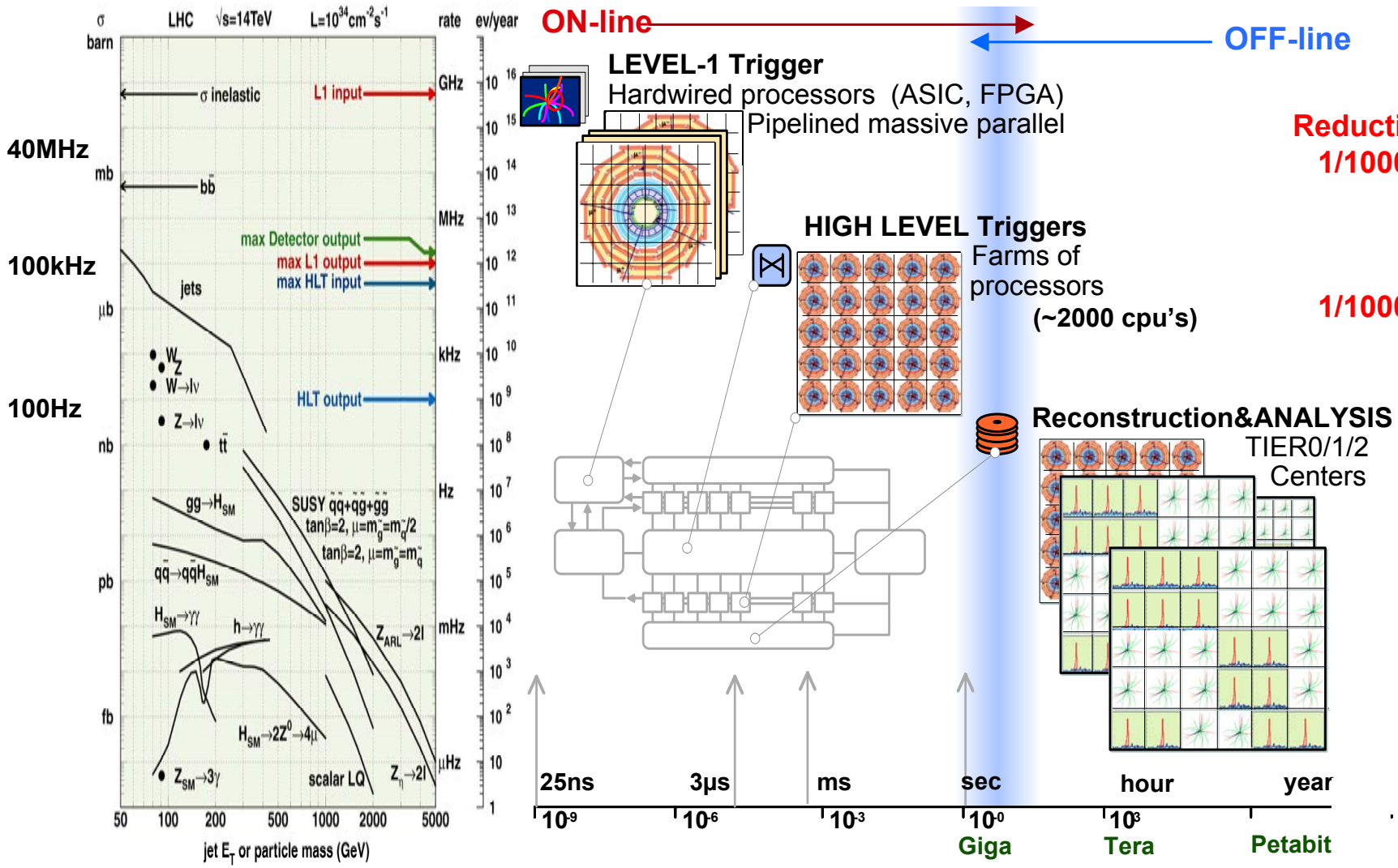
Surface buildings and main shaft

Installation of the first muon chamber



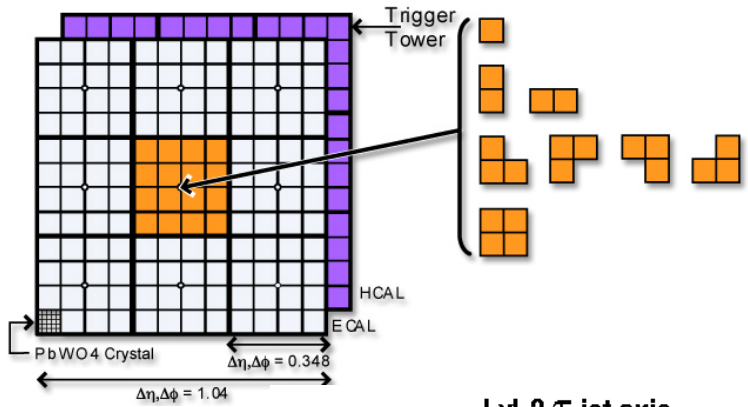
Transfer YB0 (2000t) in 2005

Physics Selection



Example: τ trigger

Level-1: calorimeter based
Look for narrow jets in pattern in the calorimeter towers.



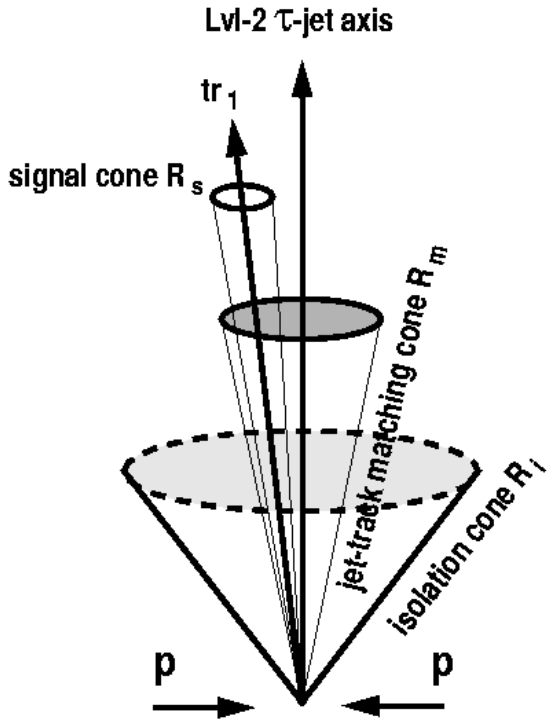
HLT (L2): two options
a) using calorimeter -purify narrow jet with fine grain ECAL .
b) using pixel tracker- look for isolated track(s) in L1 jet cone

HLT (L3): pixel and silicon strips tracker
Regional tracking - reconstruct track(s) in L2 jet cone. Six hits are enough for good momentum resolution.

H/A(200GeV) → ττ
eff =45% with QCD rejection ~ 10^6

Offline(L4): full detector information
(e.g. decay vertex)

CMS Trigger is very flexible!



HLT for Low Luminosity $2x10^{33}$ $cm^{-2}s^{-1}$

Results from full detector and trigger simulation – 7M events used in 2001-02.

Trigger	Threshold (GeV or GeV/c)	Rate (Hz)	Cuml. rate (Hz)
Inclusive electron	29	33	33
Di-electron	17	1	34
Inclusive photon	80	4	38
Di-photon	40, 25	5	43
Inclusive muon	19	25	68
Di-muon	7	4	72
Inclusive tau-jet	86	3	75
Di-tau-jet	59	1	76
1-jet * E_T^{miss}	180 * 123	5	81
1-jet OR 3-jet OR 4-jet	657, 247, 113	9	89
Electron * jet	19 * 45	2	90
Inclusive b-jet	237	5	95
Calibration etc		10	105
TOTAL			105

CMS DAQ TDR, Dec. 2002 (CERN/LHCC 2002-26)

HLT performance — signal efficiency

With previous selection cuts for low luminosity.

Channel	Efficiency (for fiducial objects)
$H(115\ GeV) \rightarrow \gamma\gamma$	77%
$H(160\ GeV) \rightarrow WW^* \rightarrow 2\mu$	92%
$H(150\ GeV) \rightarrow ZZ \rightarrow 4\mu$	98%
$A/H(200\ GeV) \rightarrow 2\tau$	45%
SUSY (~0.5 TeV sparticles)	~60%
With R_P-violation	~20%
$W \rightarrow e\nu$	67% (fid: 60%)
$W \rightarrow \mu\nu$	69% (fid: 50%)
$Top \rightarrow \mu X$	72%

Good efficiencies for low mass (100-200GeV) objects!

LHC Start up

April 2007
- LHC beam starts (4 months)
- shut down (2-3 months)

Mid-07
- First physics run (~7 months)
- 5-10fb^{-1} at 1-2 x 10^{33}cm^{-2} s^{-1}

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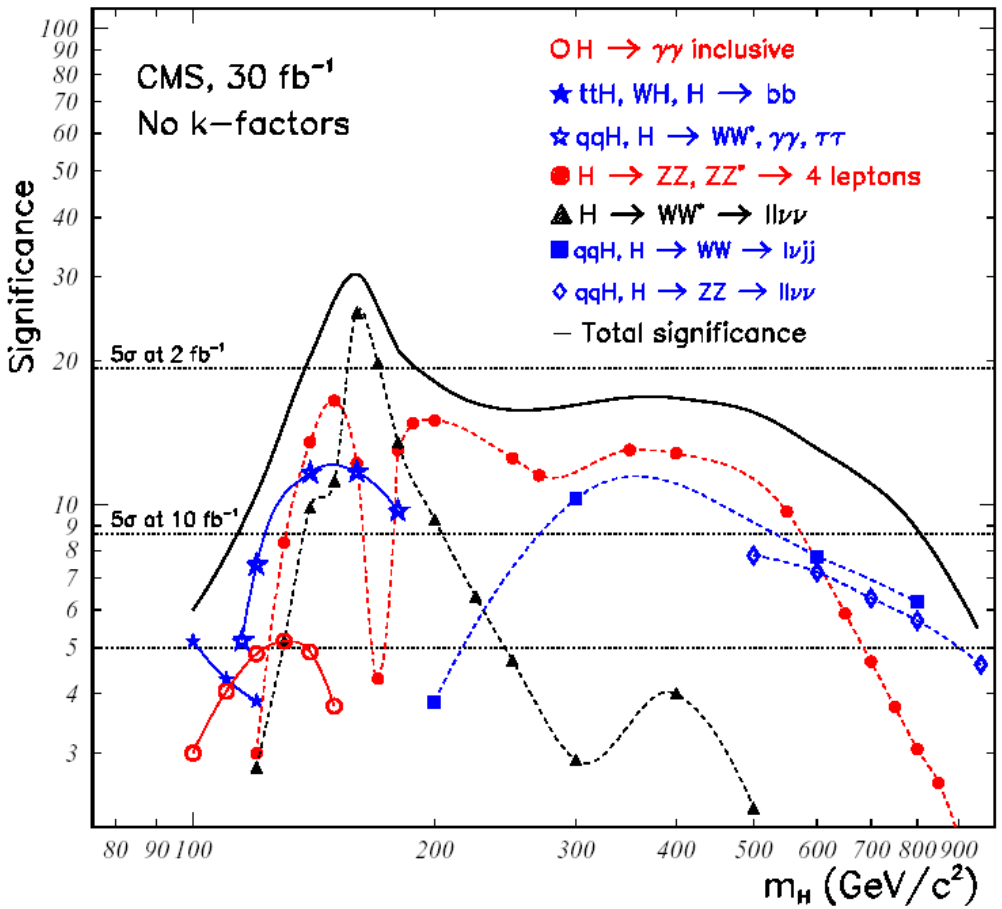
- Full luminosity run 100fb^{-1}/year at 10^{34}cm^{-2} s^{-1}

SM Higgs Discovery Range

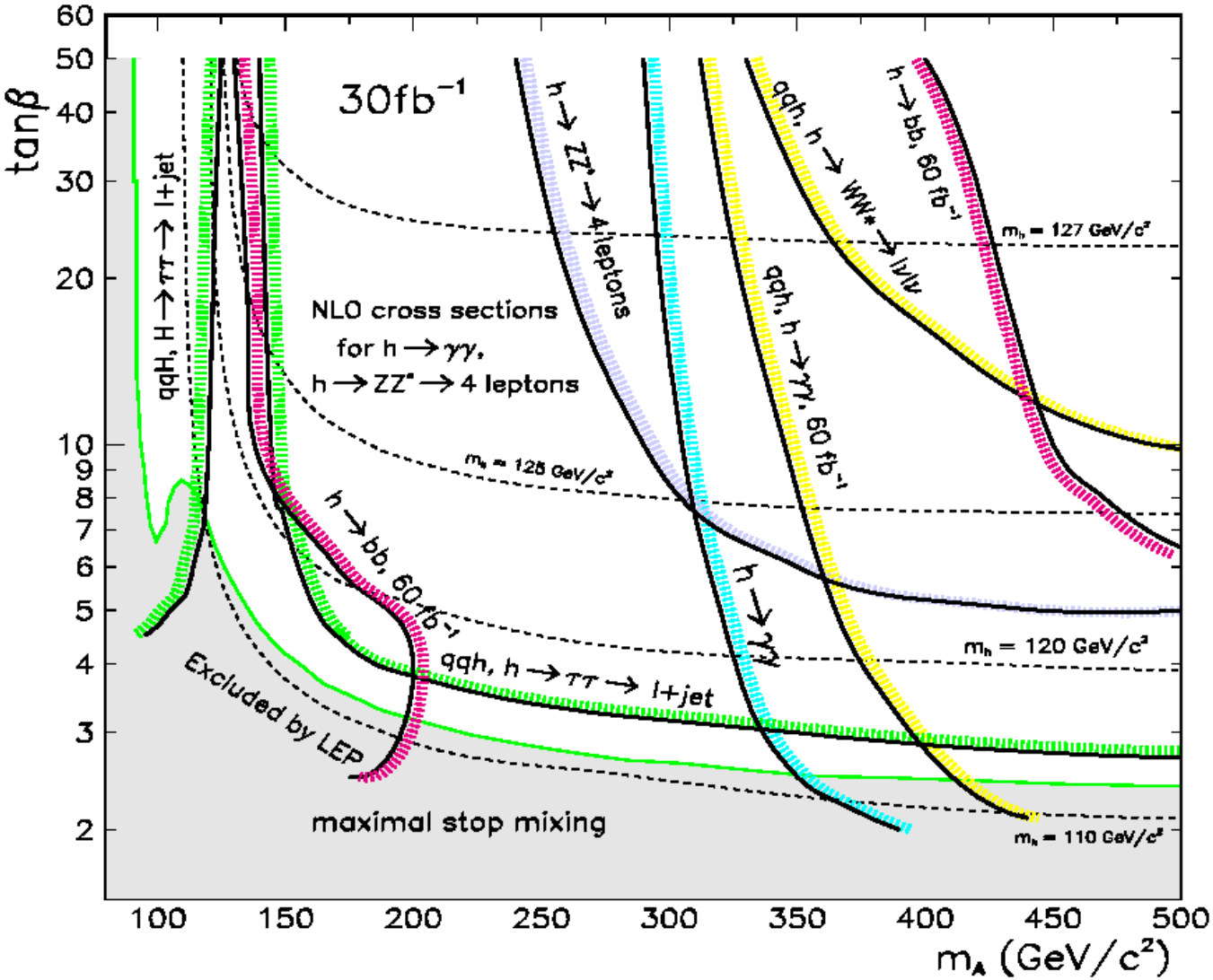


2 fb^{-1}

10 fb^{-1}

30 fb^{-1}

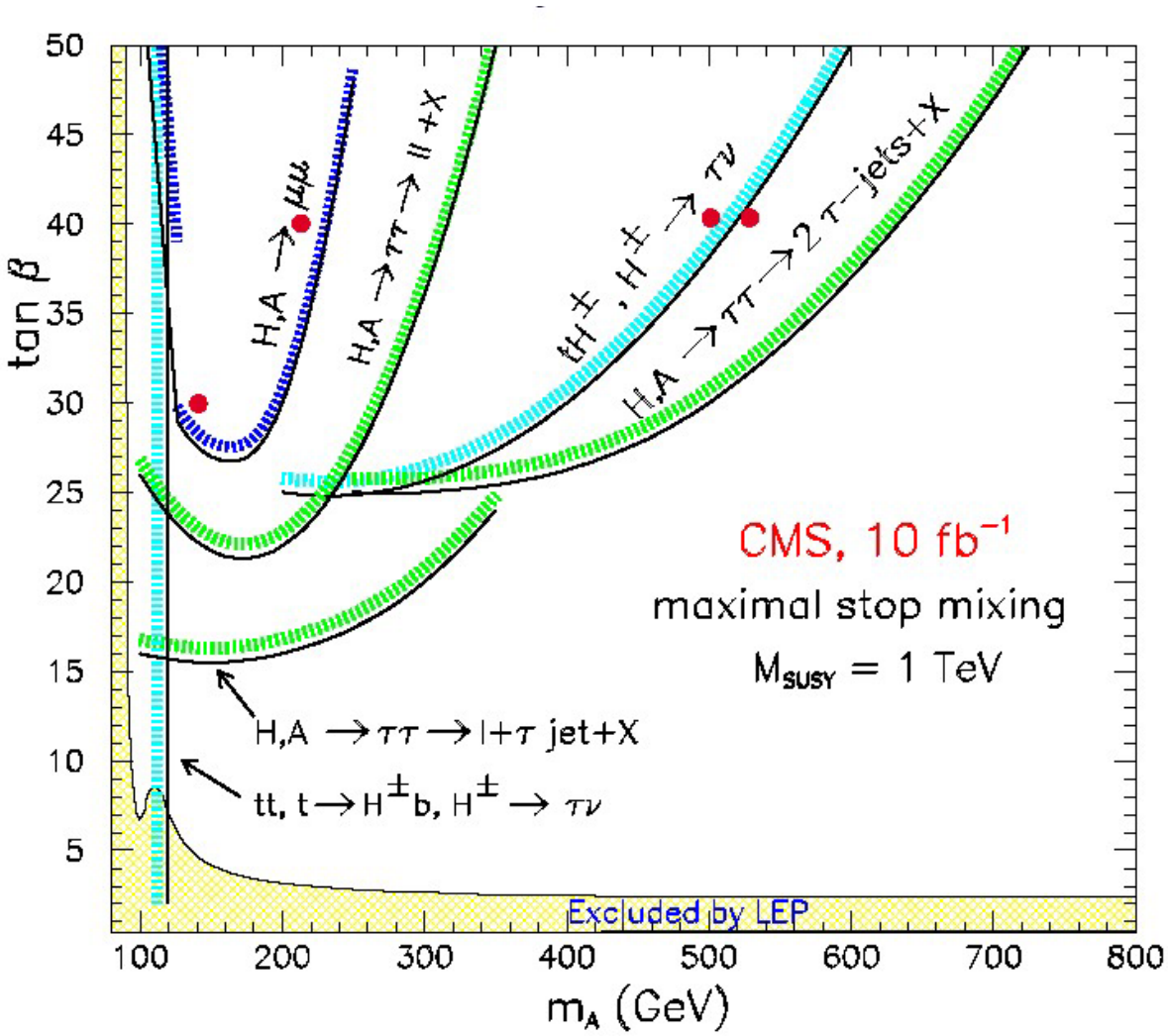
MSSM light Higgs
5σ discovery region (30 fb^{-1})



All most covered!

Need 100fb^{-1} for full coverage.

H^0/A and H^+



- neutral -

Production at high tanβ

gg → bbH⁰

Decay modes

bb dominant
but large BG

ττ BR~10%
2nd major mode

μμ BR~4x10⁻³
small, but clean

→ Good b-tagging

- charged -

Production

gg → tbH⁺

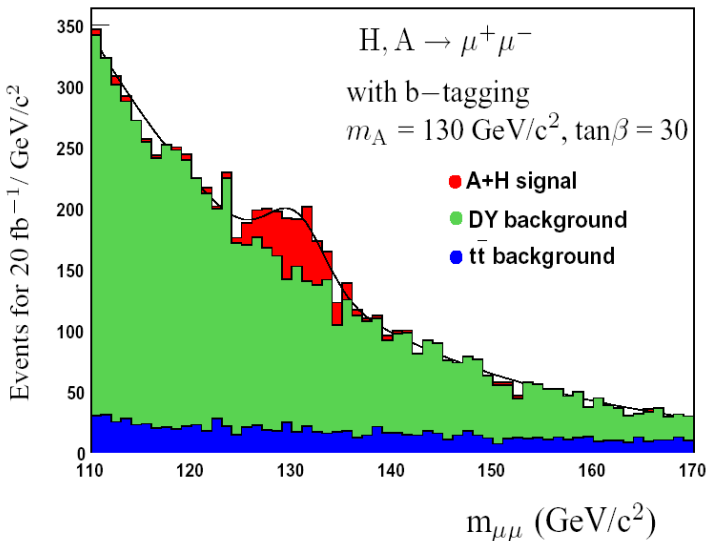
gb → tH⁺

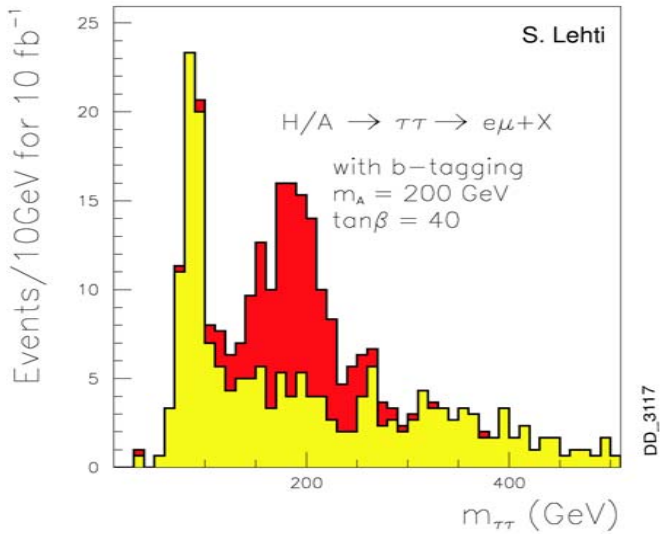
Decay modes

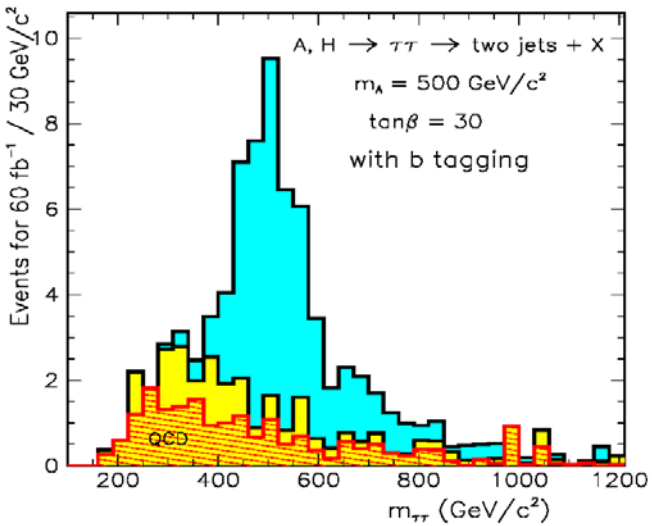
tb dominant
m>200GeV

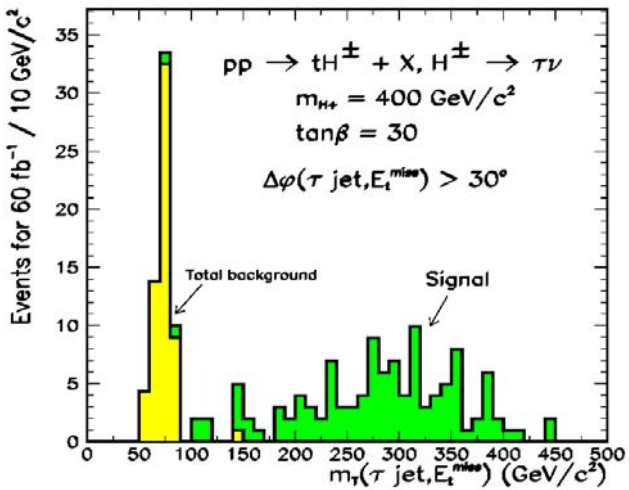
τν BR~10%
at m=400GeV

Reconstructed Mass





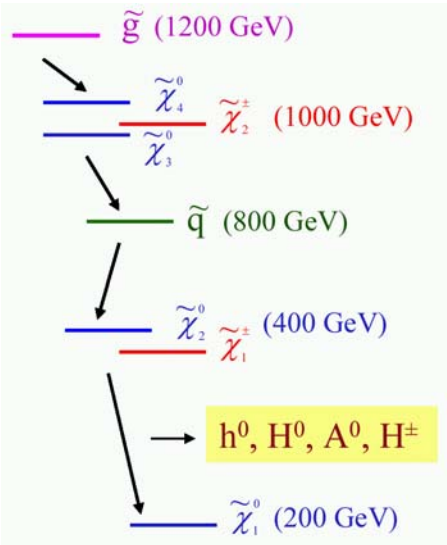




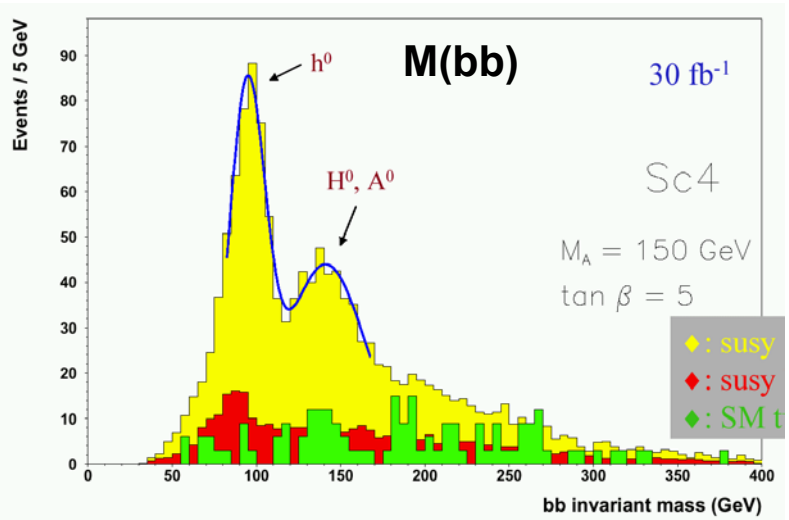
(See "Higgs Physics at LHC: R. Kinnunen's plenary talk at SUSY 2002)

Higgs in SUSY Cascades

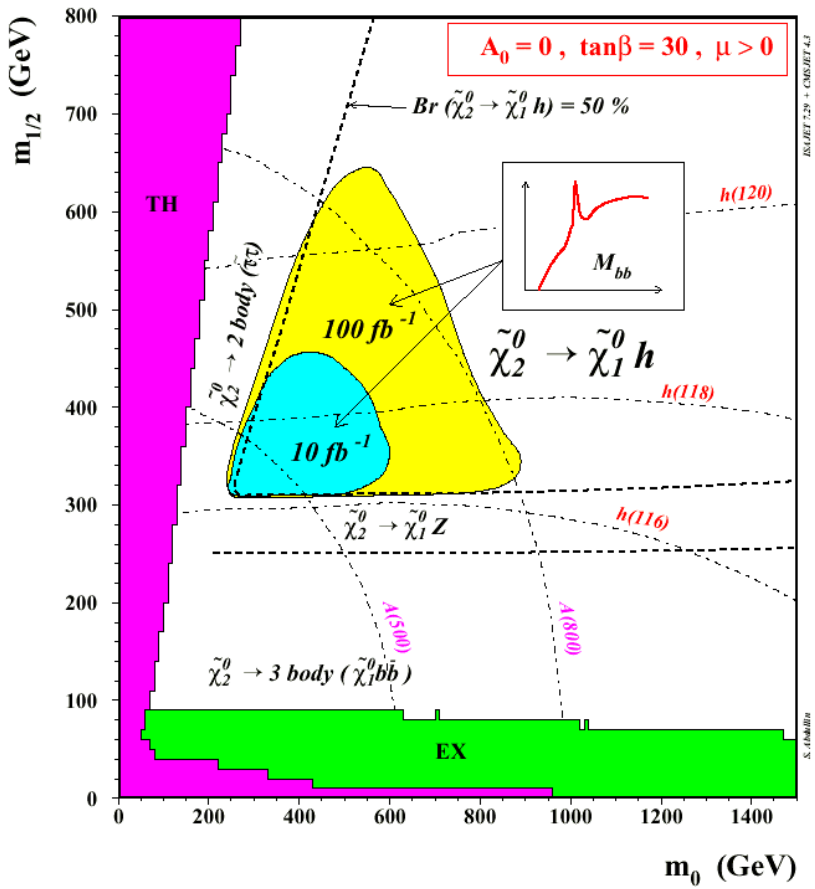
(Examples)



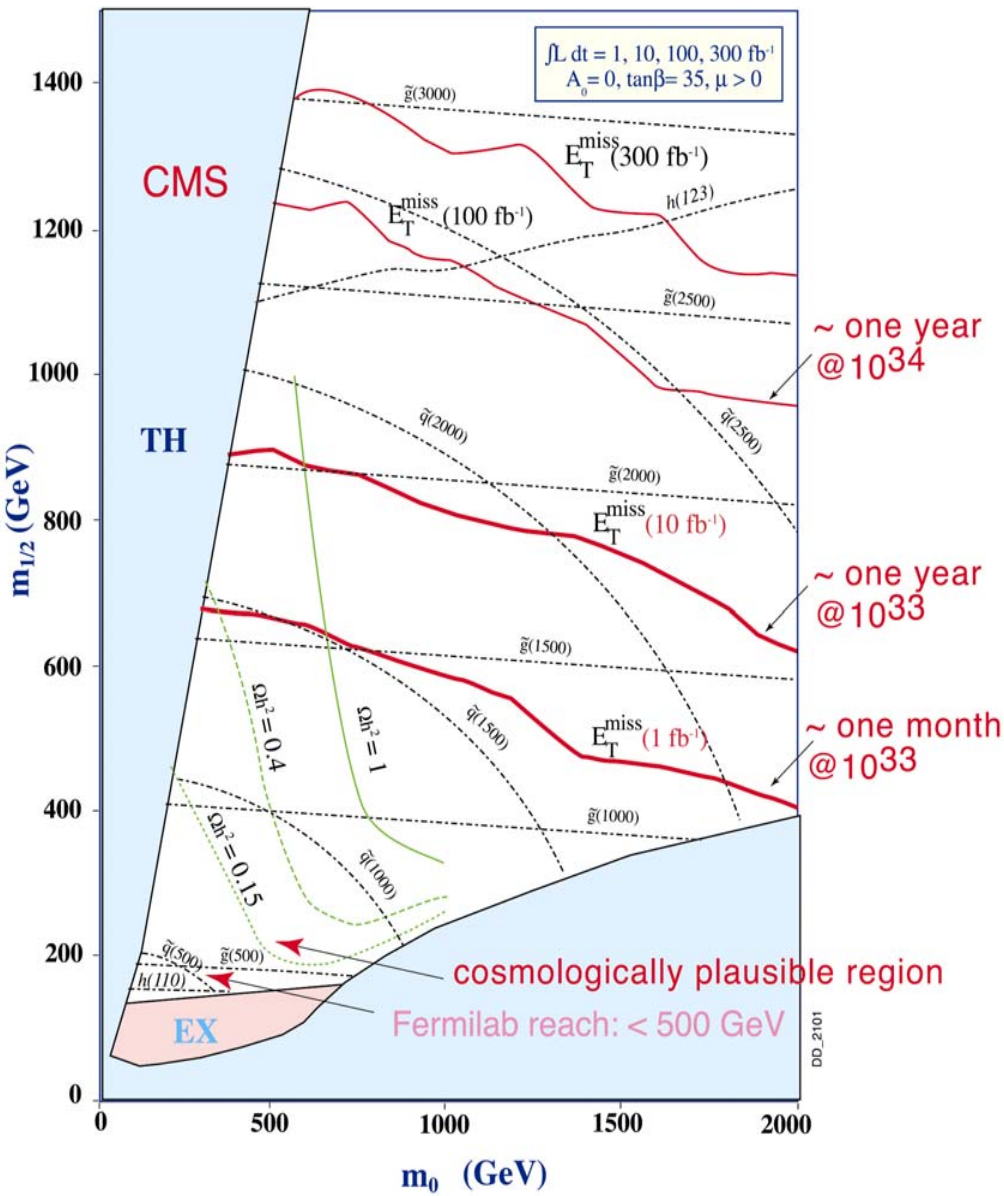
Njets>5
ET(J1)>300GeV
MET>150GeV
M(Jets+MET)>1200GeV
Two b-taggs

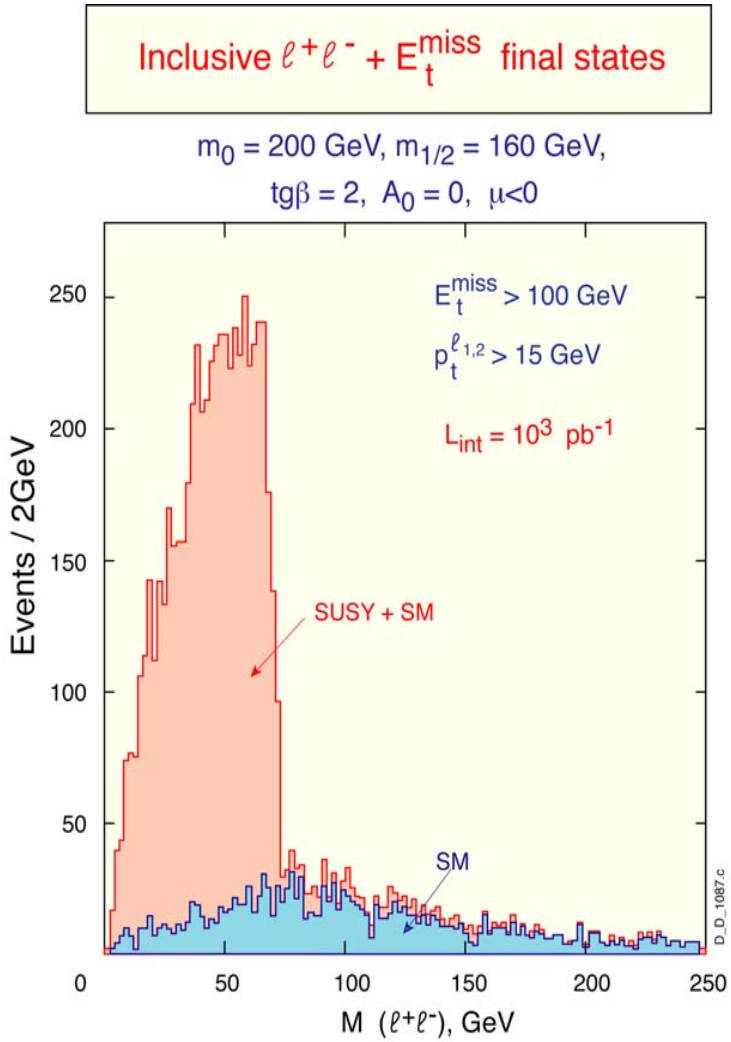


$S/\sqrt{B} > 5$



Squarks and Gluino mass reach





SUSY will be found quickly !

SUSY Spectroscopy

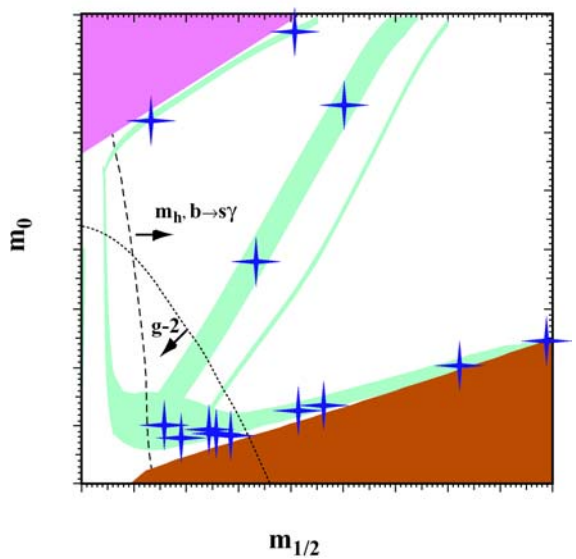
An exercise at two points using a fast parameterized simulation.

Post LEP SUSY benchmark points:
M.Battaglia et al. Eur Phys. J (2001) 535 (hep-ph/0106204)

Model	A	B	C	D	E	F	G	H	I	J	K	L	M
$m_{1/2}$	600	250	400	525	300	1000	375	1500	350	750	1150	450	1900
m_0	140	100	90	125	1500	3450	120	419	180	300	1000	350	1500
$\tan\beta$	5	10	10	10	10	10	20	20	35	35	35	50	50
$\mathrm{sign}(\mu)$	+	+	+	−	+	+	+	+	+	+	−	+	+
$\alpha_s(m_Z)$	120	123	121	121	123	120	122	117	122	119	117	121	116
m_t	175	175	175	175	171	171	175	175	175	175	175	175	175

Sparticles reconstructed in 10fb^{-1}

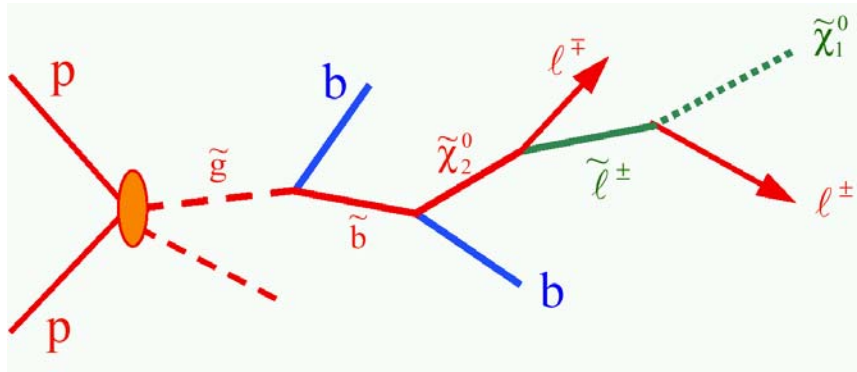
Sparticles reconstructed in 300fb^{-1}



Point B

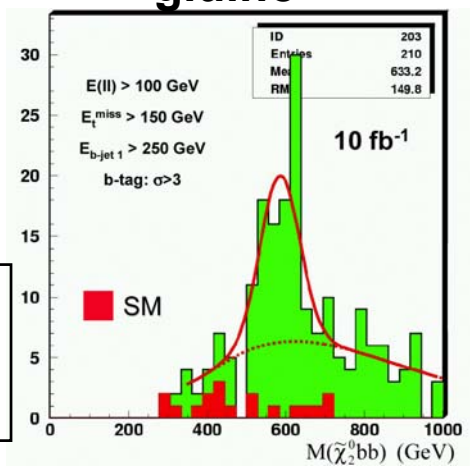
g	595.1	t_L	392.9
b_L	496.0	t_R	575.9
b_R	524.0	χ_4^0	361.1
q_L	540	χ_3^0	339.9
q_R	520	χ_2^0	174.4
l_L	196.5	$\chi_2^\pm$	361.6
l_R	136.2	$\chi_1^\pm$	173.8
		χ_1^0 = LSP	95.6

$$\sigma_{SUSY}^{TOT} = 57.77\ \text{pb}$$



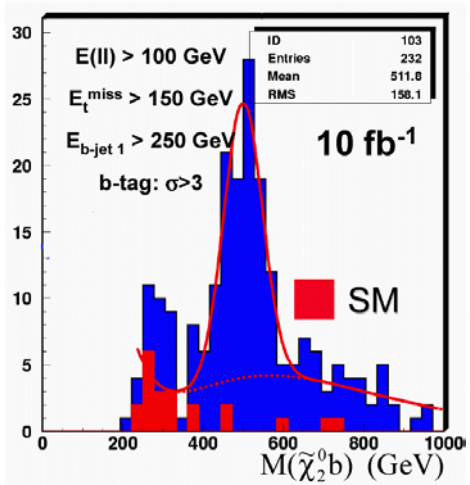
$$M_{\ell^+\ell^-}^{max} = \frac{\sqrt{(M_{\tilde{\chi}_2^0}^2 - M_{\tilde{\ell}}^2)(M_{\tilde{\ell}}^2 - M_{\tilde{\chi}_1^0}^2)}}{M_{\tilde{\ell}}}$$

gluino

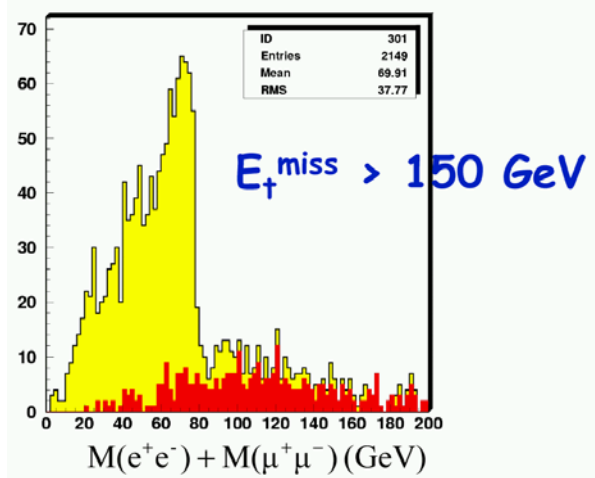


585.1 +/- 11.1 GeV

sbottom



499.4 +/- 6.6 GeV



edge 78.9 +/- 2.1 GeV

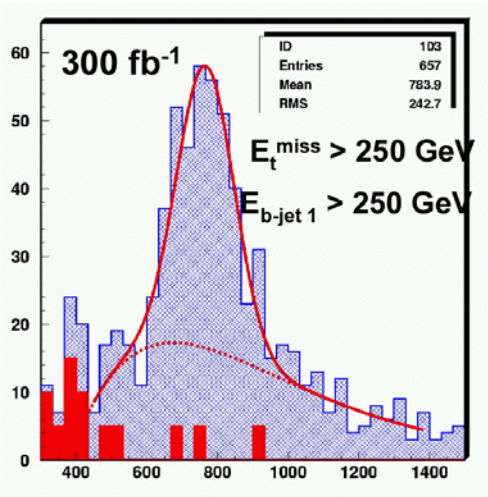
repeat for non-b squarks.

Point G

- heavier sparticles: M(squark) ≅ 800 GeV, M(gluino) ≅ 900 GeV
- lower SUSY cross section (6 pb)
- higher tanβ: smaller BR to electrons and muons. More to taus.

→ Need higher statistcis.

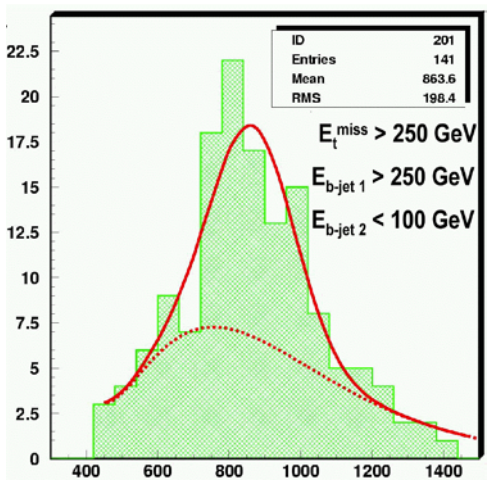
squark



$M(\tilde{\chi}_2^0 q) = 767 \pm 6$ GeV

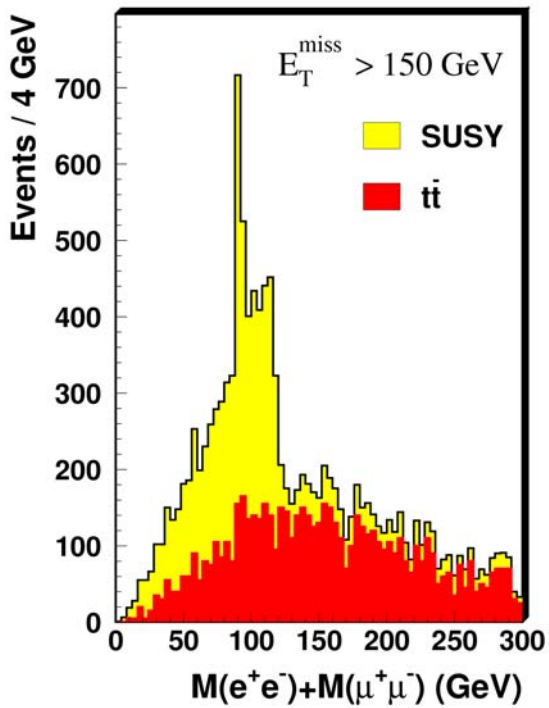
$\sigma = 80$ GeV

gluino



$M(\tilde{\chi}_2^0 qq) = 867 \pm 30$ GeV

$\sigma = 115$



Generated: $M(d_L)=M(s_L)=778.0$ GeV $M(u_L)=M(c_L)=773.9$ GeV $M(g)=860.8$ GeV

Conclusions

Machine, Experiment, computing.

"April 2007 is the target. Physics will flow rapidly afterward."

R.J. Cashmore, Director of Research, CERN.

A large discovery potential with 5-10fb^{-1} data in the first physics run.

We have developed efficient algorithms for Level 1 and High Level Trigger. The trigger is flexible and can be easily re-tuned for new physics.

Large m_A – tanβ space can be explored with 30 fb^{-1} in the MSSM Higgs boson search. Need 100 fb^{-1} to cover the full space.

Discovery of SUSY, if it exists, is almost assured at the LHC. Inclusive mSUGURA squark/gluino discovery reach to 1.5TeV with 1fb^{-1} and 2.5TeV with 100 fb^{-1} .

We have performed prototype analyses of SUSY particle spectroscopy. The results are promising. More detailed and extended studies will be done with full detector simulation and event reconstruction.

Physics at the LHC will be exciting!